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AUTHORITY

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Errata to AD 59875

Report No. 189

From Project No. 6-64-12-028

THE SPECTRAL REFLECTANCE OF HUMAN SKIN IN THE REGION 0.7-2.6 μ

by

J. A. Jacquez, J. Huss, W. McKeehan, J. M. Dimitroff and H. F. Kuppenheim

from

Biophysics Department

Submitted

15 March 1955

9 pp & i 5 illus.

Abstract;

Spectral reflectance curves for human skin are presented for the wavelengths 0.7 to 2.6 μ. The structure of the reflectance curves above 1.2 μ is dominated by the absorption spectrum of water.

REPORT NO. 189

THE SPECTRAL REFLECTANCE OF HUMAN SKIN IN THE REGION 0.7-2.6 μ*

by

J. A. Jacquez, J. Huss, W. McKeehan, J. M. Dimitroff and H. F. Kuppenheim

from

Biophysics Department
Army Medical Research Laboratory
Fort Knox, Kentucky
18 April 1955

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask, Biophysical Studies of Skin.

Report No. 189
Project No. 6-64-12-028
Subtask AMRL, S-14
MEDEA

ABSTRACT

THE SPECTRAL REFLECTANCE OF HUMAN SKIN IN THE REGION 0.7-2.6 μ

OBJECT

To obtain curves of the spectral reflectance of human skin for the wavelengths 0.7 to 2.6 μ.

RESULTS AND CONCLUSIONS

The spectral reflectances of the skin of twelve young Whites, four Negroes and two Japanese have been recorded for the range 0.7-2.6 μ. Above 1.2 μ all curves are practically identical and show primarily the absorption bands of water. Appreciable differences related to differences in pigmentation appear only below 1 μ.

RECOMMENDATIONS

None.

Submitted 15 March 1955 by:
John A. Jacquez, Capt., MC
John Huss, Pfc
Wayne McKeehan, Cpl
James M. Dimitroff, Biologist
Hans F. Kuppenheim, Chief Biophysicist

APPROVED: Ray G. Daggs
RAY G. DAGGS
Director of Research

APPROVED: William W. Cox
WILLIAM W. COX
Lt Colonel, MC
Commanding

THE SPECTRAL REFLECTANCE OF HUMAN SKIN IN THE REGION 0.7-2.6 μ

I. INTRODUCTION

Considerable data are now available on the spectral reflectance of living human skin (1, 2, 3, 4, 5) for 235-1000 mμ. Hardy and Muschenheim (6) have presented two reflectance curves of living human skin for wavelengths up to 8 μ. These were, however, calculated from comparative measurements of directional reflectance of living skin and of $MgCO_3$. No direct measurements of total reflectance for wavelengths above one micron are available, yet this region is of major interest for the study of radiation burns.

The present report presents data on the reflectance of living human skin for the range 0.7 to 2.6 μ.

II. METHODS AND MATERIALS

A. Apparatus

A spectrophotometer designed and assembled at the Naval Material Laboratory (7), improved by the addition of a comparison type integrating sphere (8), designed and built at this laboratory (9), was used for the measurements. It will be referred to as the NML spectrophotometer hereafter. This spectrophotometer is a recording instrument which uses two parallel measuring circuits; the reference detector receives a beam directly from a mirror on a chopper motor while the signal detector views the inside of the integrating sphere. Both detectors receive flux chopped at 13 cycles per second. Only the 13 cycle AC signal is measured; any DC signal due to a constant level of stray energy in the sphere is not measured. A servo system varies the entrance slit of the monochromator to maintain a constant signal level from the reference detector. The performance characteristics of this instrument with the integrating sphere have been investigated and described previously (9).

B. Method of Measurement

A sample of vitrolite from the National Bureau of Standards (V3-G38) which had been standardized against MgO was used as a working standard (9). The vitrolite was placed at one aperture of the integrating sphere and the volar surface of the forearm of the subject was placed at the other aperture. An arm rest was placed so that holding the arm to the sphere did not cause undue muscular tension.

A recording was made with the beam incident on the vitrolite and then one with the beam incident on the skin. One recording took about 10 minutes. The measured reflectance values were converted to reflectances relative to the reflectance of MgO (i.e., r_{skin}/r_{MgO})(9), and are so reported.

Reflectances were measured on the skin of 11 young white males, 1 young white female, 4 negro males and 2 young men of Japanese descent.

III. RESULTS

Figure 1 shows the extremes of the reflectance curves of the 12 Whites. The upper curve is of a very blond young male and the lower is of a very dark complexioned young male. All of the other curves for the Whites fell between these two up to 1.2 μ. Above 1.2 μ none of the curves differed significantly. Figure 2 gives the reflectance curves for the 2 Japanese males and Figure 3 the curves for 2 American Negroes. The upper curve of Figure 3 is from a very lightly pigmented American Negro whereas the lower curve is from an extremely dark Negro. For comparison with Figures 1-3, Figure 4 shows the transmittance of 1 mm of distilled water in a quartz cuvette and the reflectance of a 4.6 mm layer of a paste of 35% MgO and 65% distilled water held between quartz plates. The latter is presented to show how the presence of scattering particles makes the curve more like that of skin in the relative heights of the absorption maxima and minima. The variation between the lightest white and darkest negro in the present series is presented in Figure 5 for the range 0.4 to 2.6 μ. The data from 0.4 to 0.7 μ were obtained with the General Electric recording spectrophotometer. Note that the wavelength scale changes at 0.8 μ.

IV. DISCUSSION

As shown by the curves, the reflectance of human skin above 1.2 u is primarily the reflectance of a scattering component mixed with water. The reflectance is dominated by the absorption bands of water. Hardy and Muschenheim (10) have also pointed this out in their study of the transmission of infrared by excised skin. The 5-6% reflectance remaining at the long wavelength limit may represent Fresnel reflection at the skin surface just as in the reflectance curve in Figure 4 it represents surface reflection off the quartz plate.

In contrast to the lack of individual differences in the reflectance curves above 1.2 μ, striking differences do appear below 1.2 μ; they are correlated with differences in skin pigmentation. Extensive studies

on the region 440-1000 mμ on whites and negroes have previously been presented (4).

V. CONCLUSIONS

Above 1.2 μ, the reflectance curves of the skin of differently pigmented persons are practically identical and show primarily the absorption spectrum of water.

VI. RECOMMENDATIONS

None.

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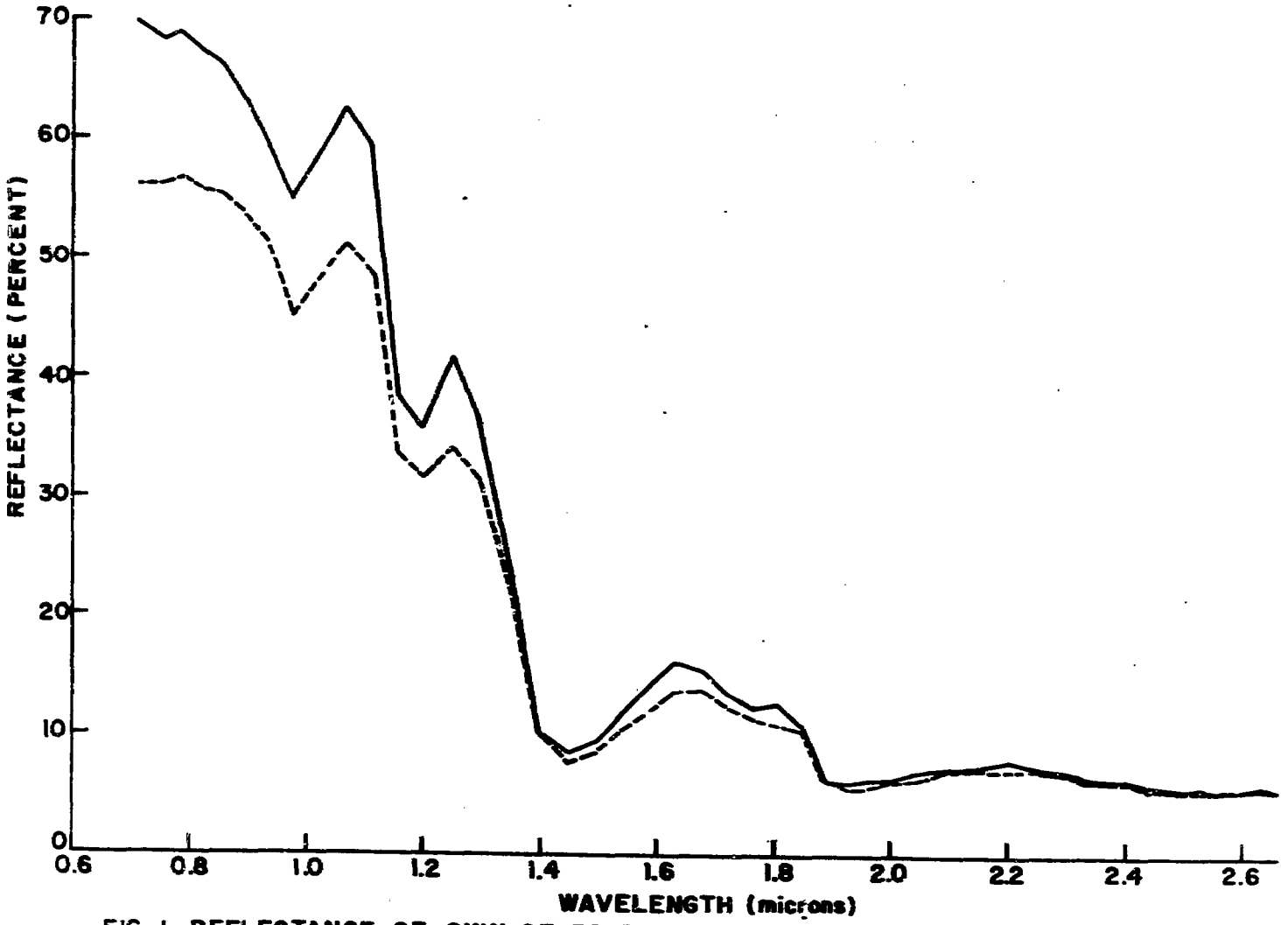

FIG. 1. REFLECTANCE OF SKIN OF FOREARM OF VERY FAIR COMPLEXIONED (——) AND VERY DARK COMPLEXIONED (----) YOUNG WHITE MALES.

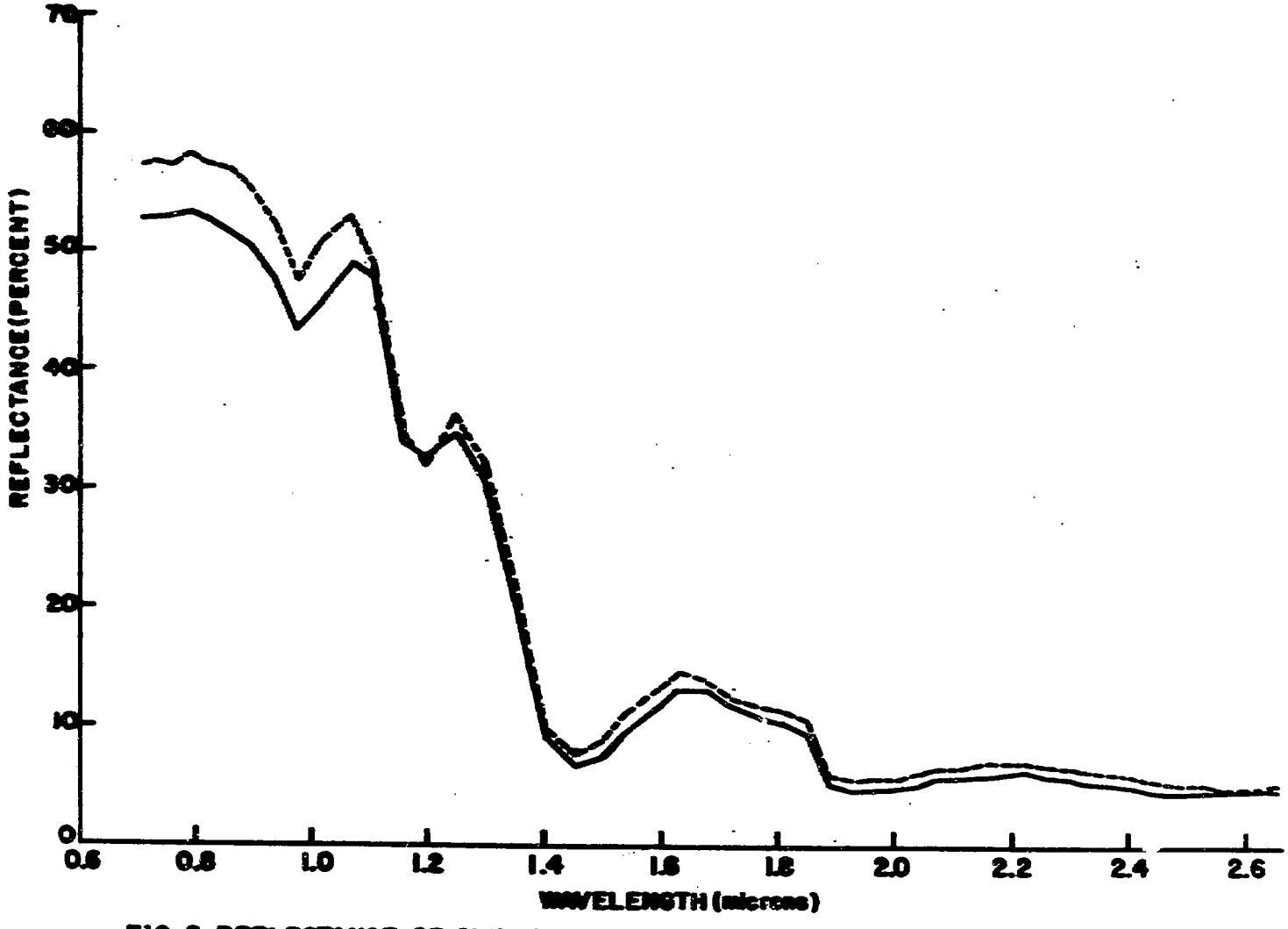

FIG. 2 REFLECTANCE OF SKIN OF FOREARM OF TWO YOUNG MALES OF JAPANESE DESCENT.

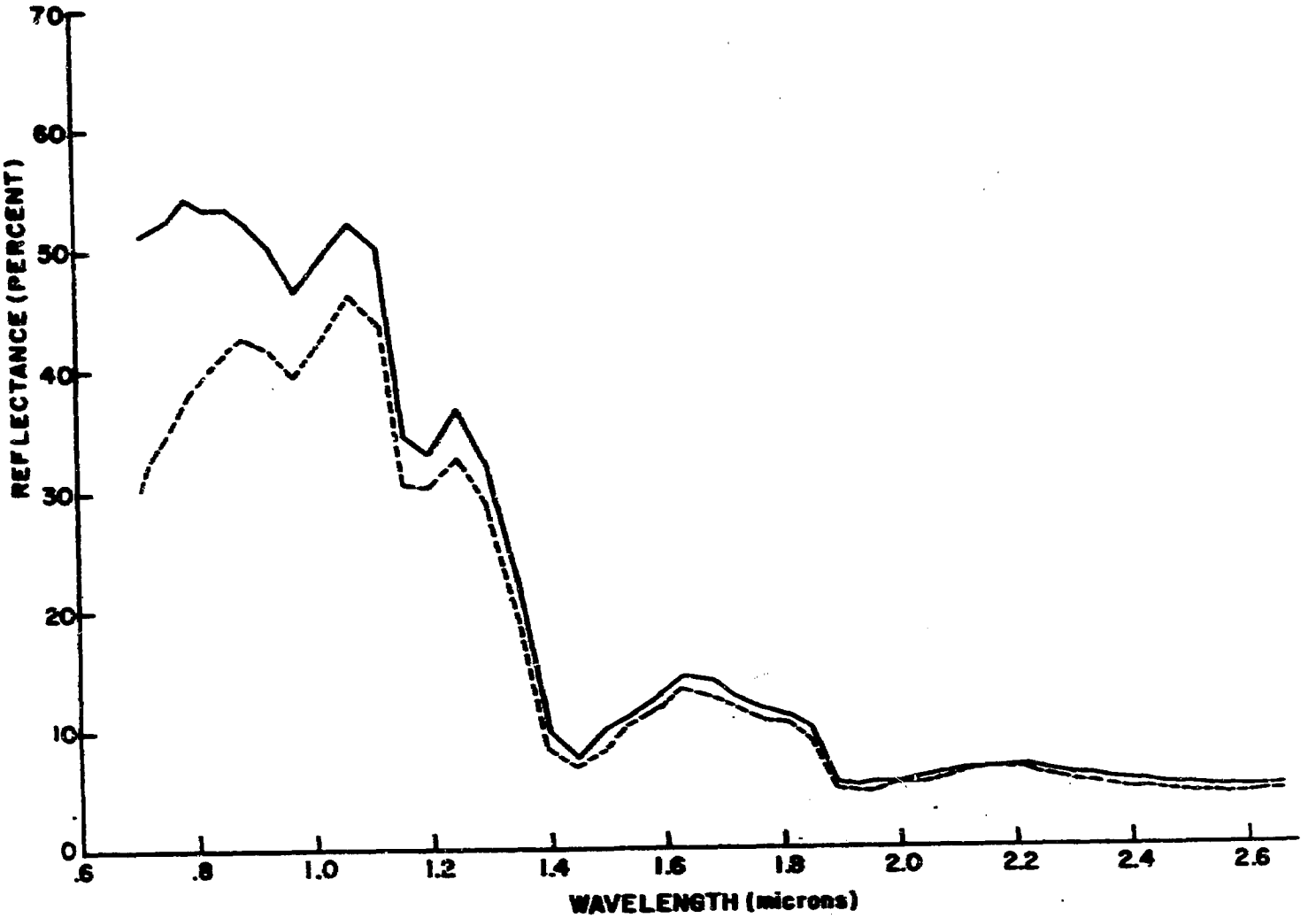

FIG. 3 REFLECTANCE OF SKIN OF FOREARM OF VERY LIGHTLY PIGMENTED(——) AND VERY DARK (----) AMERICAN NEGROES.

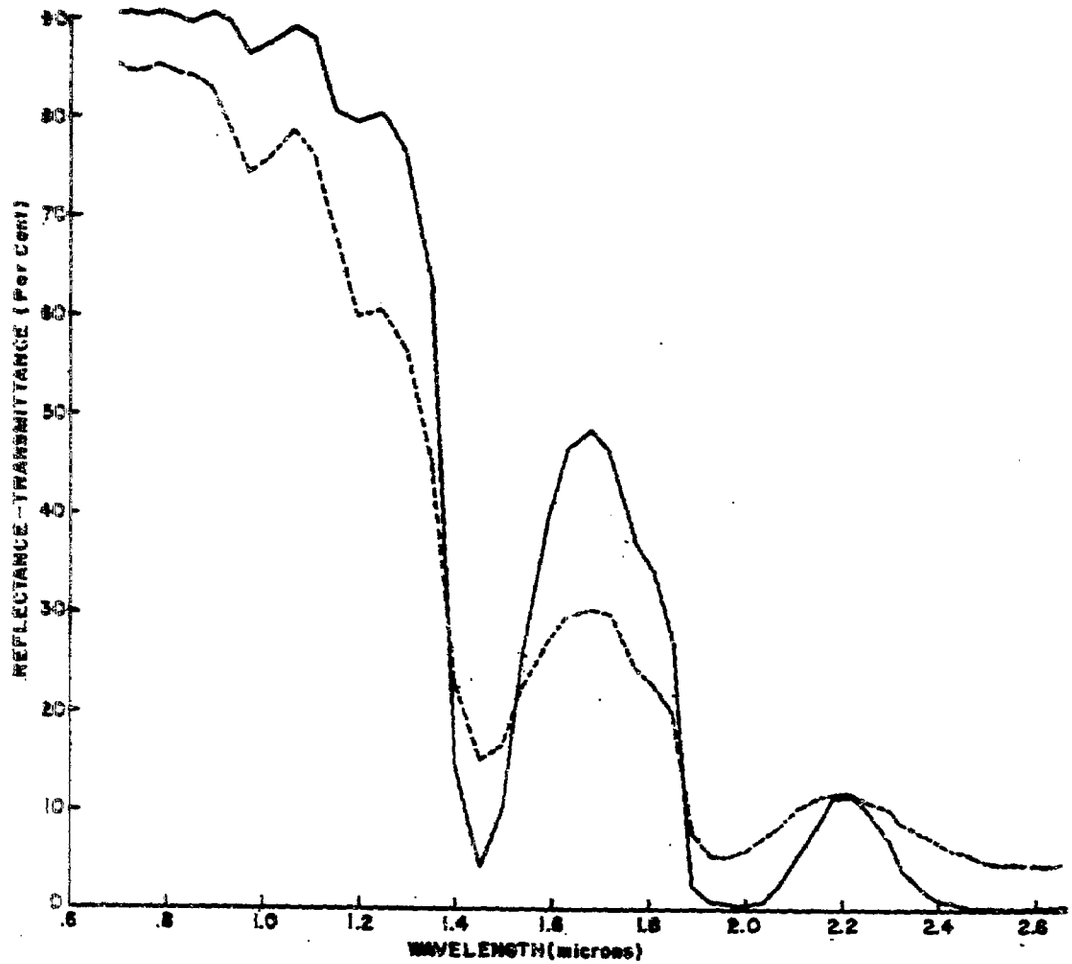

FIG. 4. TRANSMITTANCE CURVE OF 1mm DISTILLED WATER IN QUARTZ CUVETTE. (—) AND REFLECTANCE CURVE (----) OF A 4.6 mm LAYER OF A PASTE OF 35 % MgO AND 65% DISTILLED H_2O BETWEEN QUARTZ PLATES.

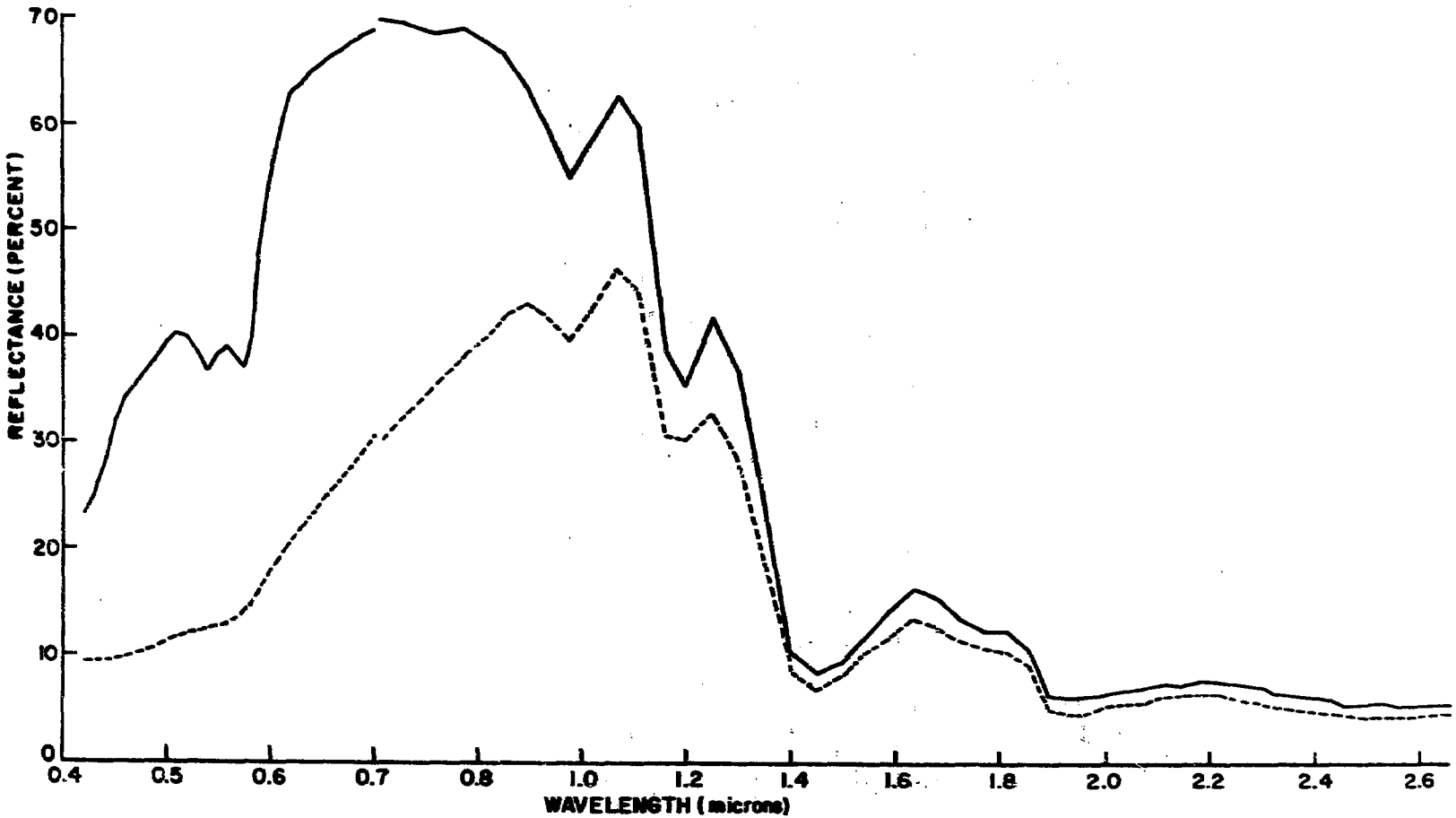

FIG. 5 COMPARISON OF VERY FAIR COMPLEXIONED WHITE(—) AND VERY DARK AMERICAN NEGRO (----) IN THE VISIBLE AND NEAR INFRA-RED.

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